Bureau canadien de la sécurité aérienne

Canadian Aviation Safety Board

Rapport d'un fait aéronautique civil

Civil Aviation Occurrence Report

Canada

The Canadian Aviation Safety Board investigated this occurrence for the purpose of advancing aviation safety. It is not the object of the Board to determine or apportion any blame or liability.

AVIATION OCCURRENCE REPORT

KENN BOREK AIR LTD.
DE HAVILLAND DHC4A CARIBOU C-GVYX
ROSS RIVER, YUKON TERRITORY
10 NOVEMBER 1987

REPORT NUMBER 87-W70073

SYNOPSIS

The pilot was attempting a single-engine approach to the Ross River Airport after the right engine had been shut down because of a loss of engine oil. An unsafe nose gear warning light illuminated, and the pilot attempted to go-around. The aircraft proceeded down the Pelly River valley for about two miles before crashing into trees along the north side of the river. Both pilots were fatally injured. The aircraft was destroyed by impact and fire.

The Canadian Aviation Safety Board determined that a lack of communication at the company's maintenance facility led to the dispatch of the aircraft with an unsuitable gasket in the right engine, and the subsequent loss of engine oil. A single-engine go-around was attempted when the combination of single-engine performance, a low cloud base, and high terrain surrounding a confined operating area made a successful overshoot uncertain. The flaps were fully retracted before the minimum speed for single-engine flight in the zero flap configuration was achieved.

Ce rapport est également disponible en français.

11 May 1989

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1.0 FACTUAL INFORMATION

1.1 History of the Flight

The de Havilland DHC4A Caribou aircraft, C-GVYX, was en route from Calgary, Alberta to Ross River, Yukon, where it was to be used to transport silver ore concentrate from the mines at Plata to Ross River. On board were two pilots, two company aircraft maintenance engineers (AMEs)* to service the aircraft, and about 5,500 pounds of aircraft parts and equipment to support the operation of the aircraft in Ross River. One refuelling stop was made at Fort Nelson, British Columbia, after which the aircraft proceeded on an instrument flight rules (IFR) flight plan to its destination.

Ross River has no published instrument approach and is situated in a valley in mountainous terrain. For an IFR flight from Fort Nelson to Ross River, it is necessary to overfly Ross River, proceed 30 miles to the northwest and complete a non-directional beacon (NDB) approach at Faro, Yukon where the minimum circling altitude is 5,060 feet above sea level (asl)** or 2,709 feet above ground level (agl). When below cloud at Faro, the aircraft may then proceed visually up the river valley to Ross River.

The Caribou arrived over Faro at approximately 1615 Pacific standard time (PST)***, and an attempt was made to descend below the cloud base which was reported to be 400 to 600 feet agl. When visual reference with the ground was not made, the pilot climbed out to the southeast and informed Faro Community Airport Radio Station (CARS) that he was proceeding to his alternate, Watson Lake.

After the aircraft levelled off in cruise flight, the right engine low-oil-quantity light illuminated. The captain instructed the engineers to look at the engine from the rear of the aircraft to confirm the warning. The engineers reported that oil was being lost from the right engine. Soon after, the right low oil pressure light illuminated. The oil pressure was allowed to drop until the pressure gauge read the minimum allowable, and the right engine was then shut down, and the propeller was feathered.

* See Glossary for all abbreviations and acronyms.
** Units are consistent with official manuals, documents, reports, and instructions used by or issued to the crew.
*** All times are PST (Coordinated Universal Time (UTC) minus eight hours) unless otherwise stated.

The route to Watson Lake passed over Ross River, and witnesses on the ground heard the aircraft circling overhead. The aircraft was heard flying out to the southeast for an approach to runway 26 at the Ross River Airport.

One of the two AMEs on board the aircraft was sitting in the jump seat between the two pilots. Although it was getting dark, this passenger could see the ground during the approach and the unlighted runway was clearly visible. Flap was selected to 14 degrees, and, on the approach, the landing gear was lowered, but no green down light showed for the nose gear. In an attempt to rectify the problem, the gear was raised and then lowered again. This time all three green indicators showed that the landing gear was down and locked, but the pilot initiated a go-around. The AME in the jump seat felt that the aircraft was no longer in a position to land by the time a safe indication was obtained on the nose gear.

Witnesses on the ground observed the aircraft overshooting and climbing in a direction about 30 degrees to the right of the runway heading, to the north side of the Pelly River, and then proceed westbound at an altitude of approximately 200 feet, close to and parallel with the north side of the valley. The aircraft passed by the town and then began to lose altitude as it disappeared in the darkness to the west. The tree-covered terrain over which it was flying was about 20 feet above the river, and, as the aircraft descended gradually into the trees, it began to roll to the right. Portions of the right wing were torn off on contact with the trees, and the roll increased to 90 degrees as the aircraft nosed into the ground. The aircraft then cartwheeled over the embankment and down onto the river shore 20 feet below.

A helicopter in the area arrived within minutes and found the two passengers, the only survivors, walking around outside the burning wreckage.

The accident occurred at lat 62°00'N, long 132°28'W at 1713 PST during the hours of darkness at an elevation of 2,320 feet asl.

1.2 Injuries to Persons

	Crew	Passengers	Other	Total
Fatal	2	-	-	2
Serious	-	2	-	2
Minor/None	-	-	-	-
Total	2	2	-	4

1.3 Damage to Aircraft

The aircraft was destroyed by impact forces and by a post-impact fire.

1.4 Other Damage

There was no other damage.

1.5 Personnel Information

	Pilot-In-Command	Co-Pilot
Age	31	27
Pilot Licence	Airline Transport	Commercial
Medical Expiry Date	Valid	Valid
Total Flying Time	6,800 hr	4,000 hr
Total on Type	90 hr	550 hr
Total Last 90 Days	150 hr	205 hr
Total on Type Last 90 Days	90 hr	205 hr
Hours on Duty Prior to Occurrence	10 hr	10 hr
Hours off Duty Prior to Work Period	13 hr	13 hr

1.5.1 Background of the Pilot

The pilot-in-command was qualified and held a valid licence. He occupied the left seat and was flying the aircraft.

The pilot-in-command joined Kenn Borek Air on 21 September 1987 and was given a company conversion course on the Caribou aircraft. This training included at least four or five single-engine go-arounds performed to the satisfaction of the instructor. All training flights were flown in an empty aircraft where a rate of climb on one engine would exceed 500 feet per minute (fpm). No attempt was made to simulate the single-engine performance of a heavy aircraft by restricting the power available on the operating engine. The pilot passed a pilot proficiency check on the Caribou aircraft on 28 September 1987 and was then taken on a company route check to the Yukon which involved drill moves and the transportation of silver ore concentrates. This took place during the month of October and involved 80 hours flying.

The pilot-in-command had been employed as a fire bomber pilot on PBY-5A Canso aircraft for five seasons and on Douglas A-26 aircraft for two seasons.

1.5.2 Background of the Co-Pilot

The co-pilot was qualified and held a valid licence. He joined Kenn Borek Air on 29 May 1986 and flew DHC6, and Beech 90, 99, and 100 aircraft. On 27 March 1987, he converted to the DHC4, completing the company conversion training and passing a pilot proficiency check on the Caribou by 03 April 1987. He had accumulated a total of 550 hours as a co-pilot on the Caribou aircraft prior to the accident.

1.6 Aircraft Information

Type	DHC4A Caribou
Manufacturer	de Havilland of Canada
Year of Manufacturer	1969
Serial Number	292
Certificate of Airworthiness	Valid
Total Airframe Time	11,185 hr
Engine Type (2)	Pratt & Whitney R2000-7M2
Propeller Type (2)	Hamilton Standard 43D50-301
Maximum Allowable Take-off Weight	28,500 lb
Recommended Fuel Type	100/130 Avgas

The aircraft was certified in accordance with Civil Aviation Regulation (CAR) Part 4B, which requires an aircraft to be able to achieve a steady rate climb of not less than 50 fpm under conditions which include the following:

(1) Wing flaps in the take-off position (seven degrees).
(2) Critical engine inoperative, its propeller windmilling.
(3) All other engines operating at the take-off power available.
(4) Speed equal to the minimum take-off safety speed V_{2min}.
(5) The weight equal to maximum take-off weight for that altitude.
(6) Landing gear extended.

The aircraft had a valid Certificate of Airworthiness. The required maintenance records and inspections were complete, and there were no unrectified defects recorded in the log books.

During the flight, the main inverter and the right windscreen heat became unserviceable. Also, the right engine was shut down by the flight crew because of an oil leak.

1.6.1 Aircraft Performance

In standard atmospheric conditions and at a gross weight of 27,500 pounds, the DHC4A has a single-engine climb capability of 270 fpm, when using 14 degrees of flap and maintaining an airspeed of 77 knots. According to information supplied by the aircraft manufacturer, the same rate of climb may be achieved with zero degrees of flap, provided an airspeed of 94 knots has been established and is maintained. The manufacturer advises that, if the speed is lowered below 94 knots, the rate of climb achieveable will reduce and eventually become negative as the total aircraft drag exceeds the thrust available, the exact cross-over point not having been determined by flight test. Experienced DHC4A pilots are of the opinion that the aircraft will not maintain altitude at heavier weights on one engine, using zero degrees of flap at some speed less than 94 knots.

The performance achieved during a one-engine go-around at near maximum gross weight would vary with pilot technique. Approximately 30 seconds would be required to accelerate from 77 knots to 94 knots in level flight as the flaps are being retracted from 14 degrees to the fully retracted position. Should an attempt be made to climb while the flaps are being retracted, the minimum zero flap speed of 94 knots may not be achieved.

1.6.2 Weight and Balance

An intense post-crash fire prevented accurate determination of the load on board. The flight crew completed a weight and balance for the flight, entering a take-off weight of 27,998 pounds in the Journey Log Book. However, this figure was based on a cargo weight of 4,000 pounds. Information supplied by the operator indicated that the cargo weighed 5,512 pounds. Based on these numbers, the gross weight at take-off from Fort Nelson, British Columbia was 29,510 pounds; about 1,000 pounds more than the aircraft's certified maximum allowable gross take-off weight of 28,500 pounds.

The duration of the flight was 3.8 hours. Allowing for a fuel burn of 700 pounds per hour, the actual weight at the time of the accident would have been about 26,850 pounds, 1,650 pounds below the maximum allowable gross take-off weight.

Due to extensive fire damage, the position of the aircraft's load was not determined, and, therefore, the centre of gravity could not be calculated.

1.7 Meteorological Information

The crew received a weather briefing from the Fort Nelson Flight Service Station (FSS) during the period 1225 and 1315 PST.

The latest Ross River weather available to the pilot at this briefing would have been the 2000Z (1200 PST) as follows:

> Estimated 2,000 feet overcast, 12 miles visibility in very light snow, temperature minus three degrees Celsius, dew point minus four degrees Celsius, wind calm.

The last weather report from Ross River, Yukon prior to shutdown of the weather office at 1400 PST was:

> Estimated 2,000 feet overcast, one mile visibility, light snow, temperature minus two degrees Celsius, wind calm.

The latest Faro weather available to the pilot at the Fort Nelson briefing would have been the 2000Z (1200 PST) as follows:

> Sky partially obscured, 1,000 feet scattered, estimated ceiling 2,000 feet overcast, visibility six miles in light snow, temperature minus two degrees Celsius, dew point minus three degrees Celsius, wind 120 degrees at three knots.

Faro, Yukon issued their last weather report for the day at 1500 PST as follows:

> 1,000 feet scattered cloud, estimated 3,000 feet broken, 9,000 feet overcast, 12 miles visibility, very light snow, temperature minus one degree Celsius, wind calm.

The Faro, Yukon weather passed by the CARS operator to the pilot as he commenced his approach was:

> 400- to 600-foot ceiling with three-quarters to one mile visibility in light snow. (The pilot replied that he had vertical visibility.)

For an alternate airport, the following forecast weather was available:

The Faro Terminal Forecast for the period 1100 to 1500 PST was:

> 1,000 feet scattered, ceiling 3,000 feet overcast, six miles visibility and light snow variable to sky partially obscured, ceiling 1,500 overcast, two miles visibility, light freezing drizzle, light snow and fog.

The Watson Lake, Yukon Terminal Forecast for the period 1300 to 2100 PST called for:

> 2,500 feet scattered cloud, ceiling 4,000 feet broken, 8,000 feet broken, occasional 1,500 feet scattered ceiling, 2,500 overcast with light rain.

At Whitehorse, Yukon, the Terminal Forecast for the period 0900 to 2100 PST called for:

> Sky partially obscured, ceiling 1,000 feet overcast, two miles and light snow, variable ceiling 500 feet obscured, one mile visibility, light freezing drizzle, light snow and fog.

A helicopter pilot flying in the vicinity of the Ross River Airport at the time of the occurrence reported the base of a lower layer of cloud at 800 feet above the ground at the airport and to the north, and 1,000 feet to the south. The visibility was 10 miles in light snow.

1.8 Aids to Navigation

The aircraft flew from Fort Nelson, British Columbia via low level airway Alpha Two to Watson Lake and then via Bravo Route 16 to Faro. The minimum en route altitude on Bravo Route 16 is 9,400 feet, and the minimum safe altitude within 25 nautical miles, southeast of the Faro NDB is 8,900 feet. The Faro NDB transmits on a frequency of 378 kilohertz (kHz), and, when used for an NDB approach, an aircraft will descend on an outbound heading of 083 degrees magnetic, carry out a procedure turn at 7,100 feet and descend inbound on an heading of 263 degrees magnetic to cross the NDB at 5,060 feet (2,709 feet agl), the minimum circling altitude. The missed approach requires the aircraft to climb on a track of 250 degrees magnetic to 8,500 feet and return to the beacon.

The pilot was planning to carry out an instrument approach to Faro and, if visual meteorological conditions existed, to complete the last 30 miles of the flight to Ross River back along Bravo Route 16 under visual flight rules (VFR). The Ross River airport is equipped with an NDB transmitting on 218 kHz. There is no approved instrument approach to Ross River using this beacon.

1.9 Communications

The Ross River CARS operates on limited hours and was not manned at the time of the accident.

The last contact with the aircraft was made by the Faro CARS operator, who kept his station open upon receiving the IFR inbound message on the aircraft. The operator passed the current weather, estimated to be a 400- to 600-foot ceiling with three-quarters to one mile visibility in light snow. During the approach, the pilot did not make visual contact with the ground, and he carried out a missed approach. On the overshoot, at 1631 PST, the pilot advised that he was proceeding to his alternate, Watson Lake and requested the latest Watson Lake and Whitehorse weather. The Faro operator passed the weather at 1633 PST, and the pilot mentioned that he might attempt a landing at Ross River on the way by, if the weather permitted.

No further contact was made with the aircraft.

1.10 Aerodrome Information

Ross River Airport is licensed as a public airport operated by the Government of the Yukon Territories. It is located at the southeast corner of the town of Ross River, at lat 61°58'N, long 132°25'W at a reference elevation of 2,314 feet. It has one gravel runway 5,500 feet by 100 feet, oriented 080/260 degrees, and has no runway lighting. High ground penetrates the visual approach slope indicator system (VASIS) approach slope approximately 2.8 nautical miles from the threshold of runway 26.

1.11 Flight Recorders

The aircraft was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR), nor was either required by regulation.

1.12 Wreckage and Impact Information

1.12.1 Accident Site

The accident site was on the north shore of the Pelly River one and one-half miles west of Ross River. At an altitude of 50 feet agl, the minimum valley width between the airport and the crash site is 5,200 feet, and, at an altitude of 150 feet agl, it is 5,900 feet. High ground rises 2,000 to 4,000 feet above the valley floor on either side. The impact area was on level ground, 20 feet above the river, and was covered with trees of an average height of 60 feet. The aircraft descended on an angle of 10 degrees with the wings level into the trees. Broken trees over a distance of 360 feet indicated that the aircraft rolled into a 90-degree bank to the right before the right engine struck the ground. A one-foot diameter tree, immediately in front of the depression in the ground made by the right engine, was sliced by the left propeller 26 feet above the ground. The right engine and major portions of the right wing remained in the immediate area. The fuselage with the left wing and engine were located on the shore of the river 20 feet below the area first struck by the aircraft.

1.12.2 Aircraft Configuration

At the time of impact, the landing gear was retracted. Measurements taken of the extension of the flap horizontal stabilizer interconnect actuator indicated that the wing flaps were set to zero degrees. Two blades of the right propeller were relatively undamaged and were in the feathered position. The remaining blade was rotated so that the back of the blade faced forward, and the blade was bent back and broken off near the root.

1.13 Medical Information

There was no evidence that incapacitation, physiological or psychological factors affected the crew's performance.

The autopsies revealed no evidence of natural disease and determined that death resulted from multiple deceleration injuries. The toxicological analysis determined the presence of carbon monoxide and diphenhydramine in the captain. The captain was a smoker, and the amount of carbon monoxide found was consistent with a cigarette smoker. Diphenhydramine is an antihistaminic found in a wide variety of over-the-counter medications. The finding of a

positive urine drug screen for diphenhydramine and a negative blood drug screen indicated that, at the time of death, there was no significant amount of diphenhydramine in the circulating blood. For this reason, it was concluded that no clinical effect would be seen from this medication. The toxicological examination of the co-pilot revealed no alcohol, drugs, or other toxic substances.

1.14 Fire

On impact, an intense post-crash fire began in two separate areas. The first fire was on the top of the river bank and was fuelled by avgas contained in a large section of the right wing. The right engine, which had separated from the aircraft, was located close to the fire and was partially burned.

The second major area of fire involved the fuselage and nacelles, which were located on the river bank. Avgas, engine oil, and oil carried as cargo fuelled the fire which destroyed the fuselage from the cockpit bulkhead to the rear loading doors. The wing centre section, nacelles, and cargo were also destroyed. No fire-fighting facilities were available, and the fire burned itself out.

Although the cargo was consumed by fire, examination of the remnants indicated that most articles remained inside the fuselage area and appeared to have been well secured.

1.15 Survival Aspects

1.15.1 Search and Rescue

The pilot of a helicopter approaching Ross River saw flames and smoke from the burning wreckage. He circled the crash site and observed two men walking on the river bank. He landed and sent two passengers to look for survivors while the two men from the Caribou were taken on board the helicopter. His passengers returned to report that they had found the bodies of the two pilots lying outside the wreckage of the Caribou. The two survivors were flown to Ross River for medical attention.

1.15.2 Crash Survival

The four occupants were thrown clear of the aircraft. The captain was restrained in his seat by his lap belt, and it was not determined if his shoulder harness was

secured. The recoil mechanism behind the seat was unserviceable. The co-pilot wore both his lap belt and shoulder harness and remained restrained in his seat. Both the captain and the co-pilot seats separated from the floor of the aircraft.

The two engineers sustained serious injuries. One engineer seated in the jump seat between the pilots does not recall how he escaped. His injuries consisted of a fractured shoulder blade and minor burns, cuts, and abrasions. The second engineer was seated in the cargo compartment on the right side of the aircraft. His injuries consisted of a compound fracture of his right arm and minor burns and abrasions. He can recall being pinned under a pine tree near fire, but he has no recollection of how he got there.

Both survivors were able to walk to the rescue helicopter that arrived shortly after the accident.

1.16 Tests and Research

1.16.1 Aircraft Engines and Propellers

The engines and propellers were recovered from the crash site for detailed examination.

The left engine was completely disassembled, and two discrepancies were noted: the oil screen was heavily contaminated with chrome steel particles, and a differential compression test indicated zero compression on four cylinders and very low compression on five of the remaining cylinders. On completion of the teardown, it was determined that the metal found in the screen did not originate from this engine. The loss of cylinder compression was traced to pine needles under the intake valves. These pine needles were found throughout the intake system and were ingested as the aircraft crashed through the trees. This engine had been in service for about 160 hours, replacing the previous engine which was removed because of metal contamination. No other significant defects were noted.

The right engine had sustained substantial fire damage to the accessory section and some impact and fire damage to the cylinder section. The engine was disassembled to determine the cause of the oil loss. A crudely formed, hand-fabricated rubber gasket was found between the governor drive pad and the governor adapter plate. The gasket was extruding from the adapter, and the governor was loose on its mount. Nuts that secure the governor were loose. The gasket was forced

completely out from between the mating surfaces at the engine oil pressure transfer port. No other discrepancy was found relating to the loss of oil.

The right propeller was disassembled to establish the actual blade angles at the time of impact. Witness marks that were left on spacers in the propeller assembly were realigned. It was determined that the blades were at an angle of approximately 90 degrees, that is in the feathered position.

1.16.2 Examination of the Governor Gasket

Laboratory testing was carried out to determine why the gasket had failed. The manufactured gasket, part number 5515-54140-A, that is required to be installed is constructed from an asbestos-filled elastomer material. It was concluded that the material used to fabricate the gasket found on the engine was nitrile rubber which has a lower tensile strength than the factory gasket. Testing and research determined that the subject gasket was compatible with the engine oil; however, this material lacked the structural strength to withstand the forces of compression and hydrostatic pressure from the engine oil.

1.16.3 Instruments and Controls

The cockpit area was separated from the rest of the aircraft, and some of its components were consumed in the post-crash fire. All of the instrument readings and switch positions were recorded at the crash site. The main section of the instrument panel was then disassembled in an attempt to recover further information. The impact forces and the direction in which they were applied were not sufficient to capture readings on most of the instruments. Some of the engine instruments retained their readings because of their method of operation. No significant information regarding airspeed, attitude, or control inputs was recovered.

1.17 Additional Information

1.17.1 History of the Right Propeller Governor Gasket

The aircraft had returned to the main base in Calgary on 01 November to have a number of defects rectified, including continuing problems with the reversing propellers. The solution to the propeller problem was to install a completely different system. Part of this change-over included the installation of an engine-driven propeller governor on each engine. When

the blanking plate was removed to accommodate the installation of the right governor, the adapter plate also came off. The factory gasket that was between the adapter plate and the engine was torn during the removal of the adapter. No replacement gasket was available in the company stores department. The AME fabricated a temporary rubber gasket to permit rigging of the governor control cable.

The AME stated that, because the gasket was to be replaced upon receipt of an approved gasket, he did not tighten the base nuts. To ensure that the engine would not be operated with the unsuitable gasket, the AME also stated that he placed a tag describing the situation, on the governor. The tag would have been the only means of communication used to identify the unfinished maintenance task. No other person was advised of the loose nuts and temporary gasket, nor was an entry made in the maintenance record.

After the apparent completion of all the required work on the aircraft several days later, a ground run was carried out under the supervision of a different AME. The right propeller governor had a substantial oil leak because of the loose base nuts. The AME found the governor loose and tightened the base nuts to rectify the problem. At this time, there was no tag on the governor. Following a test flight, a small puddle of oil was observed under the right engine. Although the captain and company chief inspector discussed this oil leak, they did not investigate to determine its source.

1.17.2 Light Conditions

On 10 November 1987, the time of official sunset at Ross River was 1621 PST. This was followed by 52 minutes of civil twilight, with the hours of darkness beginning at 1713 PST.

1.17.3 Turn Considerations

The DHC4A, flying with zero flap, at the recommended single-engine climb speed of 94 knots, would require a bank angle of 18 degrees to turn within the confines of the valley.

Flying with 14 degrees of flap, at the recommended single-engine climb speed of 77 knots, would require a bank angle of 12 degrees to turn within the confines of the valley.

2.0 ANALYSIS

2.1 Introduction

The pilot had initiated a single-engine go-around, and the aircraft had climbed to an altitude of approximately 200 feet agl before descending in a wings-level attitude into the trees. The analysis focuses on why the right engine was shut down and why the pilot was not successful in continuing flight following the single-engine overshoot.

2.2 Aircraft

The right engine oil supply was lost because an unsuitable fabricated gasket under the propeller governor adapter plate deformed, allowing pressurized engine oil to escape. The temporary fabricated gasket was not replaced because of a lack of communication between two different AMEs who worked on the right engine. The maintenance tag, the only indication of the abnormal situation, was no longer attached to the engine after the ground run. The use of a maintenance tag to identify unfinished maintenance is a normal maintenance practice. In flight, the crew shut down the engine and feathered the propeller after engine oil had been expended to the point where operating pressure could not be maintained.

The teardown inspection of the left engine did not reveal any discrepancy which would have prevented the engine from producing rated power. Metal particles that were found in the oil screen originated from residual contamination left in the airframe components following the failure of the previous engine. Loss of cylinder compression resulted during the crash sequence as pine needles were ingested into the intake system. This contamination prevented the intake valves from sealing, resulting in low compression readings during the teardown.

2.3 Weather

As the aircraft passed Ross River en route to Watson Lake, the pilot had visual reference with the ground in an area southeast of the airport and was able to descend visually until he was below the cloud base

of about 800 feet. The 800-foot cloud base would allow a visual approach to Ross River to be made; however, the combination of low cloud, night, and the steeply rising terrain surrounding the airport would make it extremely difficult to remain in visual flight conditions should a single-engine overshoot be attempted.

2.4 Terrain

The width of the valley west of the Ross River Airport and the 2,000- to 4,000-foot-high mountains on either side severely restrict the manoeuvring area available to an aircraft on a missed approach. The DHC4A carrying out a single-engine overshoot to runway 26 at Ross River would have had to turn immediately within the confines of the narrow valley in order to attempt a second approach and landing. The only other option would have been to attempt flight into a narrow and twisting valley towards Faro, as darkness approached and the ceiling and visibility rapidly decreased.

2.5 Aircraft Performance

The DHC4A aircraft meets applicable certification criteria for single-engine performance (CAR Part 4B). Nevertheless, the procedures required for climbing with a single engine when the aircraft is near its maximum weight leave little margin for error. In particular, the transition to single-engine climb from approach configuration calls for increasing the airspeed and raising the flaps. This is achieved by flying level, foregoing any attempt to climb, and postponing flap retraction until the desired airspeed is attained. Any attempt to turn could inhibit the ability of the aircraft to accelerate. It is assumed the approach, overshoot, and subsequent climb to 200 feet agl were undertaken with flaps at approach setting and at the recommended speed of 77 knots. The flaps were found in the retracted position, and, because the aircraft did not maintain height and descended into the trees, it is concluded the flaps were retracted before the necessary speed increase had been achieved.

2.6 Pilot Decision-Making - Single-Engine Approach at Ross River

After the right engine was shut down, the crew was forced to choose between two unattractive options: continuing the single-engine flight to Watson Lake, a night flight of 150 miles over mountainous terrain; or making a landing attempt sooner at Ross River.

The flight crew decided to attempt a single-engine approach and landing at Ross River in marginal meteorological conditions. The crew evidently did not realize that this decision effectively foreclosed the option of a single-engine go-around should one become necessary. The aircraft did not have sufficient single-engine climb performance to climb above the 2,000- to 4,000-foot-high terrain immediately beyond the end of runway 26. Similarly, it would have been difficult, if not impossible, to execute a safe turn within the valley. The combination of oncoming darkness and reduced visibility in snow showers would demand even greater concentration from the flight crew.

It is not known if these factors were considered prior to starting the single-engine approach to Ross River. However, if they were, the flight crew should have drawn the conclusion that an overshoot would not likely succeed and therefore should not be attempted. This conclusion would have required discussion between the two pilots and a briefing by the captain that, once the approach was begun, the aircraft would have to be put down on the runway, regardless of any additional abnormal or emergency situations.

3.0 CONCLUSIONS

3.1 Findings

1. The aircraft weight on take-off from Fort Nelson exceeded the certified maximum gross weight of 28,500 pounds.

2. The aircraft weight was below the certified maximum gross weight at the time of the accident, but the centre of gravity could not be determined.

3. The right engine was shut down in flight because of oil exhaustion.

4. Structural deformation of the gasket between the governor pad and the adapter plate caused the oil loss.

5. The rubber gasket that failed was fabricated and installed at the operator's maintenance facility as a temporary measure for maintenance purposes.

6. A lack of communication between two AMEs resulted in the aircraft being dispatched with the unsuitable gasket installed.

7. The right propeller was in the feathered position at the time of the accident.

8. The left engine was determined to have been operating normally.

9. The nose gear down-and-locked indicator light did not illuminate when the gear was selected down on final approach.

10. The pilot cycled the landing gear on short final, which resulted in a gear-safe indication.

11. The pilot initiated a single-engine go-around because the aircraft was no longer in position for a safe landing.

12. A successful overshoot was not likely given the conditions of aircraft weight, single-engine performance, weather, terrain, and darkness.

13. The flaps were raised during the climb-out prior to attaining an adequate airspeed, and, as a result, the aircraft was unable to maintain altitude.

14. The flight crew was certified and qualified for the flight.

3.2 Causes

A lack of communication at the company's maintenance facility led to the dispatch of the aircraft with an unsuitable gasket in the right engine, and the subsequent loss of engine oil. A single-engine go-around was attempted when the combination of single-engine performance, a low cloud base, and high terrain surrounding a confined operating area made a successful overshoot uncertain. The flaps were fully retracted before the minimum speed for single-engine flight in the zero flap configuration was achieved.

4.0 SAFETY ACTION

4.1 Regulatory Audit, Inspection, and Surveillance

This occurrence underlines some long-standing concerns of the CASB with respect to the effectiveness of Transport Canada's processes for regulatory control of operations and maintenance. Apparently despite the best efforts of Transport Canada, the occurrence record continues to demonstrate a need for a more effective regulatory presence - particularly for companies engaged in remote operations.

After an accident in May 1985 involving a Kenn Borek Air Ltd. aircraft (Report No. 85-W54056), the Government of the Northwest Territories advised the CASB of its concern about the safety record of this company. In July 1985, the CASB advised the Minister of Transport that there was some basis for this concern based upon the company's accident statistics. The Department of Transport subsequently completed a comprehensive audit of the company, culminating in a full range of recommendations which addressed company management practices in flight training, aircraft maintenance, and operational procedures. In light of the positive steps taken or in progress as a result of this audit and review of company operations, the CASB was assured by Transport Canada that the deficiencies in operations and maintenance at the company were being satisfactorily addressed.

Two recommendations resulting from the Transport Canada audit were that "management adopt a more dynamic approach to monitoring all aspects of operations and maintenance" and that "management institute procedures to ensure that aircraft weight limitations are complied with ...."

Notwithstanding these recommendations, the accident aircraft departed Fort Nelson approximately 1,000 pounds heavier than the aircraft certified maximum allowable gross take-off weight. There was also some indication that the engines of the accident aircraft may have been involved in frequent heavy-lift operations; some evidence of overheated cylinders may possibly have been due to over-boosting. Furthermore, since the accident in May 1985, Kenn Borek Air Ltd. has experienced five other incidents in addition to this accident. (Two of the incidents involved materiel defects in the landing gear systems [CASB Report No. 87-C74015 and 88P0269]. The other three incidents raised questions about pilot operating technique [CASB Report No. 86-W64029, 86-W64066, and 87-W74108].)

In May 1988, Transport Canada conducted a routine maintenance audit of the Calgary base of Kenn Borek Air Ltd. Although the company was noted to have "shaped up very well", several discrepancies were noted concerning the need for the company to "ensure maintenance manual procedures are being complied with" and for "engineers to review the procedures in Section IV of the Company Maintenance Manual and Air Navigation Order (ANO) VIII No. 2." The audit also noted that improvement was required with respect to dual inspections being carried out by qualified personnel and being properly certified in the aircraft logs. The audit gave no indication about whether certifications were being made in the journey logs in accordance with ANO II No. 4 or whether all log book entries were in accordance with ANO VIII No. 2 and 3.

The Board has noted several other occurrences which call into question the adequacy of Transport Canada's surveillance, audit, and inspection of operations and maintenance in remote regions. Three years earlier, in October 1984, a Wapiti Aviation Limited Piper PA-31-350 Navajo Chieftain descended in cloud below the minimum obstruction clearance altitude and struck high terrain during an approach to High Prairie, Alberta (CASB Report 84-H40006). In its report, the CASB stated that

> "One of the primary safety deficiencies identified in the accident was the inability of TC to respond effectively to the apparent unsafe operating practices of a company, despite an abundance of evidence: in the two years preceding the accident, regional Air Carrier Inspectors had expressed concern about the safety of the company; Airworthiness Inspectors discovered numerous irregularities in the maintenance procedures and record keeping of the company; and ATC personnel issued IFR clearances to company aircraft for off-airways flight during conditions of IFR weather to an airport that was not served by an instrument approach. The Board is concerned that the ineffective identification and reporting of apparent unsafe practices, and/or a lack of coordination between divisions of TC may continue to degrade the effectiveness of routine surveillance, despite the enhanced sophistication of the current surveillance policy."

The Board further recommended that the Department of Transport ensure "there are adequate internal directives to fulfil the objectives of Regional Master Surveillance Plans; and that there is adequate coordination between the Air Navigation and Aviation Regulation directorates to provide effective surveillance (CASB 86-18)."

Following an accident in June 1987 involving an Air Toro de Havilland Beaver (CASB Report 87-H70002), it was found that there was inadequate follow-up by Transport Canada to discrepancies noted by Air Carrier Inspection personnel following the company's base inspections in 1985 and 1986. Consequently, the CASB recommended that "the Department of Transport improve procedures for the follow-up to any outstanding items from the audit of a company's operations (CASB 88-31)."

In September 1987, the CASB forwarded an Aviation Safety Advisory to Transport Canada citing several examples of alleged substandard workmanship by some aircraft repair shops as reported to the Confidential Aviation Safety Reporting Program (CASRP). During CASRP field liaison visits across Canada, several aircraft maintenance engineers (AMEs) raised the subject of poor or improper maintenance practices by some overhaul shops and the need for more monitoring to ensure that standards are maintained. This Advisory called into question the adequacy of Transport Canada's routine surveillance and inspection procedures for overhaul and repair facilities. Because some of the reported irregularities and maintenance work could result in serious airframe or powerplant failures, the Advisory suggested that Transport Canada:

"a. invite owners to immediately report examples of inadequate workmanship to regional airworthiness authorities;

b. conduct an independent study to assess the frequency and gravity of the maintenance irregularities as reported to CASRP; and

c. consider strengthening surveillance and inspection requirements for monitoring the adequacy of workmanship by overhaul and repair facilities."

To date, Transport Canada has not replied to this Aviation Safety Advisory.

In summary, the CASB is concerned that Transport Canada's current program for the audit, inspection, and surveillance of operations and maintenance procedures of companies engaged in remote operations is not adequately identifying and resolving potentially dangerous safety issues. The installation of a non-approved part on the accident aircraft in conjunction with the apparent lack of communication between AMEs, possibly due to inadequate documentation of work completed, and the evidence indicating continued operations above maximum certified gross weights are particularly disconcerting in light of the special attention given by the regulatory authorities to Kenn Borek Air Ltd. since May 1985. Looking beyond this particular accident, the CASB has been concerned for some time about the adequacy of regulatory verification of workmanship in aircraft repair shops. Evidence received by the CASRP strengthens these concerns, as reflected by the CASB's Aviation Safety Advisory of September 1987. The Board recognizes that more regulation is not necessarily required. Rather, the issue is one of maximizing the effectiveness of Transport Canada's regulatory efforts. Therefore the CASB recommends that:

> The Department of Transport cause an independent study to be made of Transport Canada's policies and procedures for the audit, inspection, and surveillance of the operations and maintenance functions of air carriers engaged in remote operations.
>
> (CASB 89-05)

4.2 Other Safety Concerns

4.2.1 Pilot Decision-Making

The Board is once again concerned that decisions made by two experienced and competent pilots led them to a situation from which recovery was not assured. Neither the option to divert 150 miles at night over mountainous terrain on a single engine nor the option of an immediate single-engine approach in oncoming darkness and marginal weather to an airport in a confined valley were attractive, and it would be difficult to fault a decision either way. Nevertheless, once the decision to land at Ross River had been made, the conditions demanded the utmost in crew coordination to plan the approach and a possible missed approach. All descent and approach planning would have had to be completed before the aircraft descended below the level of the surrounding hills in order to preserve an adequate margin of safety. The

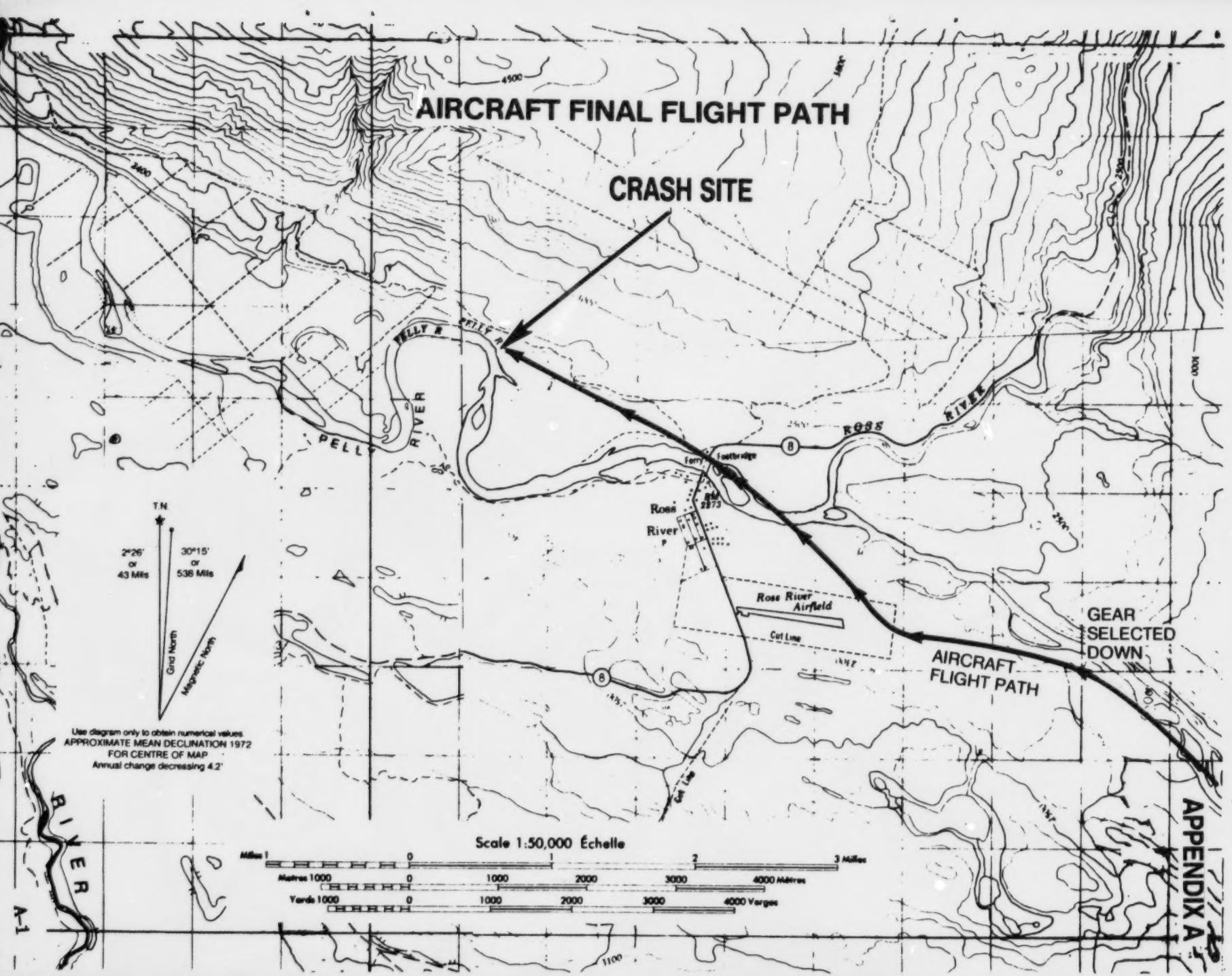
CASB will continue to develop its understanding of the human factors which contribute to decision-making and the role of cockpit resource management in arriving at sound decisions.

4.2.2 Pilot Training

The Board is concerned that, given the high turnover of pilots in the smaller companies in the current economic climate, the level of pilot knowledge and proficiency on particular aircraft types may be less than desirable. The captain of the accident aircraft had only 90 hours on type, and there is no evidence that he had practised single-engine go-arounds at heavy aircraft weights with the associated limited rates of climb. To have successfully effected a single-engine go-around under the accident circumstances would have required a thorough familiarity with the aircraft's limited single-engine climb and turn performance. Furthermore, pilots may not fully appreciate the decrements in the performance of an aircraft as it ages as opposed to that of a brand-new airframe which was used to derive the data provided by the manufacturer for certification purposes. The Board will continue to monitor the occurrence record for evidence of inadequate pilot familiarity with aircraft performance capabilities and operating procedures.

This report and the safety action therein has been adopted by the Chairman, K.J. Thorneycroft, and Board Members:

N. Bobbitt
L. Filotas
W. MacEachern
A. Portelance
R. Stevenson
F. Thurston


AIRCRAFT FINAL FLIGHT PATH
CRASH SITE
PELLY RIVER
ROSS RIVER
Ferry
Footbridge
Ross River
Ross River Airfield
Cut Line
GEAR SELECTED DOWN
AIRCRAFT FLIGHT PATH
APPENDIX A
A-1
T.N.
2°26' or 43 Mils
30°15' or 536 Mils
Grid North
Magnetic North
Use diagram only to obtain numerical values
APPROXIMATE MEAN DECLINATION 1972
FOR CENTRE OF MAP
Annual change decreasing 4.2'
Scale 1:50,000 Échelle
Miles
Metres
Yards
4000 Mètres
4000 Yards

LIST OF LABORATORY REPORTS

The following laboratory reports were completed:

LP 261/87 - Photogrammetric Analysis of Terrain

Hanson Materials Engineering - Investigation of Failed Gasket

These reports are available on request from the Canadian Aviation Safety Board.

GLOSSARY

agl	above ground level
AME	aircraft maintenance engineer
ANO	Air Navigation Order
asl	above sea level
CAR	Civil Aviation Regulation
CARS	Community Airport Radio Station
CASRP	Confidential Aviation Safety Reporting Program
CVR	cockpit voice recorder
FDR	flight data recorder
fpm	feet per minute
FSS	flight service station
hr	hour(s)
IFR	instrument flight rules
kHz	kilohertz
lat	latitude
lb	pound(s)
long	longitude
NDB	non-directional beacon
N	north
PST	Pacific standard time
UTC	Coordinated Universal Time
VASIS	visual approach slope indicator system
VFR	visual flight rules
V_{2min}	minimum take-off safety speed
W	west
Z	zulu
°	degree(s)
'	minute(s)